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ABSTRACT

This paper describes a collaborative research study designed to determine whether well-constructed tasks in mathematical inquiry with the use of methods in dialogic discourse help students' retention of mathematical concepts in probability. The paper reports on an experiment conducted in two classrooms in an urban school district in the Pacific Northwest. One teacher taught a fourth and fifth grade combination in a low-income area, and the other taught a second grade class in a middle to high socioeconomic status area. Over a period of 2 weeks, students were introduced to activities using penny flips and spinners designed to engage students in inductive learning methods on probability. Dialogic discourse was used to engage students in conversations about the results of their activities. Interviews were conducted of observers regarding their perceptions of student learning from the discourse in which the students engaged. Two weeks later, students responded to a written prompt asking them to describe the activities and what they had learned from them. Responses varied in depth and specificity, but all students responded positively to at least one of the concepts taught using the vocabulary of probability indicating that the activity or the discourse of a combination of the two resulted in retention of a portion of the mathematical concepts presented to the children. (Author/SLD)

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The Role of Discourse in Mathematical Inquiry

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Abstract

This paper describes a collaborative research study designed to determine if well-constructed tasks in mathematical inquiry with the use of methods in dialogic discourse help students' retention of mathematical concepts in probability. Specifically, the paper describes an experiment conducted in two classrooms in an urban school district in the Pacific Northwest. Over a period of two weeks, students were introduced to activities using penny flips and spinners designed to engage students in inductive learning methods on probability. Dialogic discourse was used to engage students in conversations about the results of their activities. Interviews were conducted of observers regarding their perceptions of student learning from the discourse in which the students engaged. Two week later students responded to a written prompt asking them to describe the activities and what they had learned from them. Responses varied in depth and specificity, but all students responded positively to at least one of the concepts taught using the vocabulary of probability indicating that the activity or the discourse or a combination of the two resulted in retention of a portion of the mathematical concepts presented to the children.

The Role of Mathematical Inquiry and Discourse

There is an increasing body of literature supporting the benefits of mathematic discourse. Can engaging students in meaningful tasks in mathematical inquiry be used as a means of "unpacking the relationship between the functioning of discourse and students' understandings of mathematics" as it is suggested? (Knuth, 2000). The use of discourse as a "thinking device" is diametrically opposed to the "univocal" or lecture method engaged in by some teachers of mathematics. Woods (1998) and Knuth (2000) describe the traditional patterns of communication of teachers of mathematics as univocal. Univocal dialogue is characterized by a teacher conveying exactly what he/she wants the students to know and how the teacher wants the students to respond. Suggestions made by the teacher are not meant to be a thinking device, but more for directing or correcting. In the univocal method, meaning is conveyed rather than explored. Questions are framed for one word or yes/no responses by the learner. Conversations are converged as the teacher listens for errors and directs students to answer in a specific way. Brendefur and Frykholm (2000) describe this method of discourse as "uni-directional."

Dialogic discourse encourages pursuit of inquiry not initially expected. It is characterized by the teacher rephrasing a student's response for clarity, using student responses to generate new meaning, and using utterances as thinking devices. In dialogic discourse, students and teachers share mathematical authority. The teacher uses student ideas to extend discussions by use of probing questions to press students for extended

understanding. Knuth (2000) maintains that "all discourse is to some degree both dialogic and univocal in nature; in a sense, it is helpful to think of discourse being more or less dialogic or univocal in nature."

METHODS

In an effort to determine if well-constructed tasks in mathematical inquiry and dialogic discourse can help students' conception of mathematical concepts in probability, two teachers from two different schools in the same urban school district conducted the same two inductive activities with their classes and compared the results. The materials used in this study were taken from the same trade book for use in both classrooms (Cuomo, 1993). One teacher teaches a fourth and fifth grade combination class in a Title I school. The other teacher teaches a second grade class in a middle to high SES area. The activities were conducted over the course of a two-week period of time. In each case, the teachers asked another educator to observe and take notes on the process and comments made by both the students and the teachers. During the activities, transcripts were taken of the discourse between the teachers' and the students' by these other educators. In an effort to triangulate the data, transcripts were coded, each teacher conducted an interview of their observer/recorder, and students were asked to respond to a prompt about what they learned from the activity two weeks after the lessons were taught.

In the first activity, the students explored the probability of getting heads and tails when they flipped a penny twenty times. First, the students watched a demonstration of how to generate and record the data. In both classrooms, the teacher demonstrated the activity and univocally conveyed the exact method for gathering data. Then, the students

grouped in pairs, made a prediction of how many heads and how many tails they would get out of the twenty tries. At this point the teachers did not engage students in a discussion of the mathematical concepts to be investigated. After conducting the activity and recording the data, the results were discussed with the students in a whole group setting. Teachers attempted to use the dialogic methods by rephrasing student responses for clarity and probing for understanding.

In the second activity, students made spinners divided into three equal parts which they colored red, yellow, and blue. Using the spinners, the students played a racing game to see which color would "win" most often. Students recorded the winners of the races on a class graph as the games were played. After this activity, students were encouraged to compare the results of the class and engage in a discussion of why the results looked as they did.

An extension of the second activity was to make spinners that were divided into eight equal parts, however, one-half of the area was colored blue while red and yellow each covered one-fourth of the area. Again, a class chart was created to record the "winners" of each of the races and the discussion of the results centered around this part of the activity was a comparison of the results from the races using both of the spinners.

ANALYSIS

The penny flip activity brought a variety of responses from the students. Conceptual understanding of the probability of equal chances was just emerging at the end of the activity for both groups of students. Initially, students in both classes tended to focus on their predictions rather than the class results. For students in the second grade class the word "chance" was never used, but conceptual understanding was indicated by

the terms "50/50" and "half and half." Students in the fourth/fifth combination class readily used the term "chance" in association with "50/50" and "even chances."

The penny flip and spinner activities were the foundation of conceptual understanding of prediction and probability. Students' conceptual understanding was still at the level of emersion during the first spinner activity, but this activity was paramount to building on the foundation. During this activity, students were still making their predictions based on their favorite colors rather than analyzing the spaces and colors on the spinner.

Through the course of the second spinner activity, the students' use of the vocabulary relating to probability began to be more readily used. This use of vocabulary was an indicator of conceptual understanding. Second grade students used such comments as "blue has four chances out of eight," "yellow only has two chances of the wheel stopping on it," and "the one with the most sections will win. It helps you guess if you see the spinner first and look at the colors and spaces." The fourth and fifth graders' comments included: "Blue has more chance of winning because it has four triangles and they are all even. And since they are all even, it just makes it so blue will win," and "There is definitely more blue than red and yellow...it doubles the chances of hitting blue than red and yellow." Other students began to relate their discourse back to the previous penny flipping and spinner activities. A fourth grade student observed, "We had three colors. So if all three were even, they would all have the same possibility of winning. The same chance, equal chance if they were all the same size just like the pennies did." The discourse between the fourth and fifth grade students at this point led to a discussion

of percentages and decimals and how they are related. The discourse in the second grade led to a discussion of "fair" and "unfair."

Following these lessons, interviews were conducted by each teacher of their recorder/observer. Observers were asked to respond by giving their insights regarding the process by which the students explored the probability concepts and the differences in the ways struggling learners and more advanced learners grasped the concepts. One observer stated that in the first lesson, students

> were beginning to grasp the concepts. They were using language such as 'same chance' and 'percentages' in their discussions. By the second lesson, they were getting there. They were right on the edge. They were using the words 'equal chances' and were able to observe that there would be a difference in the data collected if the parts weren't equal.

This was reinforced by the dialog between the students.

Comments were made by the observers about the differences between the ways struggling learners and more advanced learners grasped the concepts. One such comment was:

> It appeared that the more advanced students grasped the concepts and were willing to make conjectures much sooner than lower ability students, but their question, statements, and conjectures helped lower ability students.

The other observer stated:

> Struggling learners matched the learning to something in their environment. They related the comments to previous learning by giving

concrete examples. Others were able to grasp the concept verbalizing their connection to the activity.

Two weeks after these activities, the students were given a prompt to write about what they learned from the activities they were given to complete in probability and their discourse. After a gap of two weeks, students in both classes were still able to verbalize the concepts of probability in at least one of the activities in which the students engaged. Some of the students were able to use the specific vocabulary in their responses. One second grader stated, "I learned probability is the most likely guess." Another wrote, "I learned that if there are more of one color, then that one will win." A struggling second grader wrote, "I learned that a spinner can be fair and unfair."

Fourth and fifth grade students comments included: "What I learned was that if you have a spinner and it has more of one color, you have a better chance of getting it. When you flip a coin, it has a fifty/fifty chance of getting it." Another student wrote: "What I learned about the penny flip was how a 50/50 chance works and how to collect and chart data. A 50/50 chance is when you have the same chance of one thing that you do of another thing." A struggling learner wrote, "I learned that a 50/50 chance is an even chance."

CONCLUSION

This study is important in showing that well-written inductive instruction in probability lends itself to the use of dialogic discourse. Conceptual meaning is constructed through the use of discovery and dialogic discourse. Discourse was the tool used to help students connect the meaning of the experience and the concept. By using more dialogic discourse than univocal discourse, students were able to construct and

articulate ideas as they built upon the concepts. The penny flip and spinner activities were foundational to conceptual understanding of prediction and probability. While the activities were foundational, the dialogic discourse was paramount in leading to the construction of long-term retention of the concepts. The scope of this study was to pair inquiry activities with the dialogic discourse. Further study would need to be conducted to determine if the inquiry activities or the discourse contributed more to the retention of the concepts.

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